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DCP-S-026
Baseline
March 2, 1999

DRYDEN CENTERWIDE PROCEDURE

CODE SH

ELECTRICAL SAFETY

Electronically Approved by:
Associate Director

Approved by:
Acting Director, Safety and Mission Assurance

Approved by:
Chief, Safety, Health, and Environmental Office

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1.0 INTRODUCTION

1.1 Purpose

This Dryden Centerwide Procedure (DCP-S-026) establishes basic policies and guidance for operations involving operational and programmatic electrical activity at DFRC. It also defines responsibilities of managers, designers, users, installers, and others who service or operate electrical power sources and equipment.

1.2 Applicability

DCP-S-026 applies to government and non-government personnel at DFRC and at DFRC controlled off-site operations.

1.3 Scope

DCP-S-026 establishes procedures and defines responsibilities to control and protect government and non-government personnel and NASA resources when working with or near electrical sources at DFRC controlled locations.

2.0 APPLICABLE DOCUMENT

2.1 Authority Documents

NPD 87102B; NASA Safety and Health Program Policy. This NPD establishes the requirements for the NASA wide safety and health program and is the authority for the DFRC Safety and Health Manual.

29 CFR 1910, Subpart S; Electrical. This CFR is the primary authority document governing electrical safety in most industrial settings. Exclusions to this CFR include aircraft, motor vehicles other than mobile homes and recreational vehicles, and certain activities conducted by electrical and communication utilities. For complete exclusions see 29 CFR 1910.302 (2).

29 CFR 1926, Subpart K; Electrical, and Subpart V; Power Transmission & Distribution. These CFRs are the authority governing certain activities when working with electrical sources primarily in construction settings. These include: 1) Installation safety requirements. 2) Safety related work practices. 3) Safety related maintenance and environmental consideration. 4) Safety requirements for special equipment.

National Fire Protection Association 70: National Electrical Code (NEC). This code establishes the majority of safety procedures used in an industrial setting such as that found at DFRC. It provides specific procedures for nearly every electrical application. Every person working with electrical sources or equipment at DFRC must have access to this document. For interpretations or questions regarding NEC contact the DFRC Safety Office.

2.2 Guideline Documents

NHB 7320 1B, Facilities Engineering Handbook; Chapter 8, Electrical Engineering Criteria. This NHB contains the basic engineering criteria and design guidance for the construction, operation, and maintenance of all electrical systems inside and outside the building limits of field installations.

OSHA Training, Electrical Course 203/309A This OSHA course is an excellent means of acquiring knowledge on how to work safely with electricity . It may be used by electrical service supervisors for classroom and on-the-job training and for review by electrical service personnel.

NHB 1700.1 (V1-B), NASA Safety Policy and Requirements Document. This Central Agency document contains policy, safety requirements and guidelines that define the NASA Safety Program.

MIL-HDBK- 454, General Requirements for Electronic Equipment. Guidance for electrical systems design, operation, and maintenance to control hazards that are likely to cause death or serious physical harm or severe system damage.

ANSI/IEEE 18: Shunt Power Capacitors.

ANSI/IEEE C2: National Electrical Safety Code.

ANSI/NEMA 250: Enclosures for Electrical Equipment (2000 V Max.)

ANSI/IEEE 516: Disconnect poles (Hot Sticks).

ANSI Z41: Protective Footwear.

ANSI Z89.1: Industrial Workers Protective Headwear.

ANSI Z87.1: Eye and Face Protection.

IEEE 450: Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations.

IEEE 484: Practice for Installation Design and Installation of Large Lead Storage Batteries for Generation Stations and Substations.

ASTM D-120, Standard Specifications for Rubber Insulating Gloves.

CAL-OSHA, Title 8, Subchapter 5, Group-2: High Voltage Electrical Safety Orders.

Underwriters Laboratories, Inc. (UL).

2.3 Associations

Associations that publish electrical safety guidelines for specific applications are:

National Electrical Manufactures Association (NEMA).

Electronics Industries Association (EIA).

Insulated Power Cable Engineers Association (IPCEA).

3.0 DEFINITIONS

3.1 Ampere: the unit for measuring the rate of flow of electricity.

3.2 ANSI: American National Standards Institute.

3.3 Alternating Current (AC): the type of current in which the electrons move to-and-fro in the conductor. The rate of the change of flow is measured in cycles per second, i.e., 60 Hz means the flow changes 60 times per second. AC can be transmitted over long distances and is, therefore, the type of current used commercially.

3.4 Conductor: a material through which an electrical current can travel. Most metals are conductors. Copper and aluminum are examples of very good conductors.

3.5 Direct Current (DC): the type of electric current in which the movement of the electrons are in one direction through the conductor. DC is often associated with batteries. The electrical system in your car is mostly DC. DC cannot be transmitted economically over long distances.

3.6 Electric Current: the flow of electrons through a conductor.

3.7 Hazardous Classified Location: an area that due to its function causes a hazard to exist if electrical sources are not properly used. Examples of a hazardous

classified location may include an aircraft hanger, facility where explosive dust is created, a fuel farm where explosive fumes and vapors could exist, etc.

3.8 IEEE: Institute of Electrical and Electronic Engineers.

3.9 Insulator: a material through which an electric current does not pass easily. Some good insulators are polystyrene, mica, glass, certain types of rubber, and dry wood.

3.10 NFPA: National Fire Protection Association, includes NFPA 70, National Electrical Code, (NEC).

3.11 NRTL: National Recognized Testing Laboratory, such as Underwriters Laboratories, Inc. (UL).

3.12 Resistance: the opposition of a conductor to the flow of electrons due to "friction" inside the conductor. Resistance is measured in ohms (Ω).

3.13 Volt: the unit for measuring the force that drives current through a conductor.

4.0 ROLES AND RESPONSIBILITY

4.1 Overview

The chain of responsibility for ensuring that there is a safe work environment at DFRC that follows required safety standards, regulation, codes, and guidelines starts with the Center Director and flows downward through management and supervisors. In addition, each person who works at DFRC must understand that a "condition of employment" is to observe all safety requirements applicable to the task being performed.

4.2 Directorates and Single Letter Offices

Ensure persons under their supervision receive appropriate electrical safety training and follow electrical safety procedures when working with electrical sources. Electrical power sources that require special handling and training generally include equipment using or disbursing 600V or greater but may be lesser depending on the specific operation/s being conducted.

4.3 Chief, Safety, Health, and Environmental Office

Is responsible for oversight of the DFRC electrical safety program and will:

- Advise management on matters concerning electrical safety.

- Ensure adequate local safety policies are written for the control of electrical sources.

- Investigate accidents and incidents and report findings to management and required agencies.

- Review this DCP annually for necessary revisions.

4.4 Electrical Service Supervisors

Electrical service supervisors are responsible for the safety of the persons working under their supervision and will:

- Ensure that employees under his/her supervision are properly trained and/or certified to perform the tasks assigned them.

- Provide proper personal protective equipment (PPE) and ensure each that each employee is trained to use it.

- Follow this DCP and other regulations, codes, and instructions that impact the specific task being accomplished.

4.5 Electrical Maintenance Personnel

Electrical maintenance personnel will:

- Be trained and/or certified to perform assigned tasks.

- Be able to recognize the hazards associated with a task and know how to minimize the risks by using proper procedures, tools, and PPE.

- Follow regulations, guidelines, policies, and codes applicable to the work they are performing. Should an employee have any questions regarding procedures or electrical safety they will consult their supervisor or the DFRC Safety Office before continuing.

4.6 Line Supervisors will:

- Inform workers of the location of electric sources or equipment that could pose a potential hazard within their work area.

- Ensure employees are trained to recognize the potential electrical hazards in their work area and how to avoid such hazards.

4.7 DFRC Personnel will:

- Only perform electrical work for which they are trained and authorized .
- Follow applicable electrical safety procedures such as shop directives, those in this DCP, and supporting documents.
- Utilize appropriate tools and PPE.
- Report any known or suspected electrical safety hazards to supervisor or the Safety Office.

5.0 PROCEDURES

5.1 General Safety Rules

5.1.1 Qualifications: only qualified and authorized individuals are permitted to perform electrical work at DFRC. A qualified person is one who has the required skills, training, and knowledge to perform electrical work safely. Such individuals must be aware of the hazards associated with electrical work and the methods for reducing the risk of accidents that can result from unsafe conditions or acts. See Section 9.0; TRAINING AND CERTIFICATION, for training requirements.

5.1.2 System Isolation: electrical systems shall be considered energized until verified to be de-energized and grounded or other appropriate actions are taken to ensure the system is de-energized. Verification that low voltage equipment is de-energized can be made by using an approved voltage test device. For grounding requirements and exceptions see NFPA 70, Article 250; Grounding.

5.2 Electrical Equipment Switching Order

Before starting work on high voltage equipment, of 600V or greater, the designated supervisor will develop a work plan and make it available to persons who will work on the equipment. The plan will include, as appropriate:

- Diagram or drawing of the electrical system to be worked on.
- Lockout/tagout procedures to be taken.
- A high voltage switching order for isolation, grounding, and restoration of power. When very high voltages are involved (above 2300V) the

Facilities Maintenance Electrical Engineer will approve the switching order for both isolation and restoration of power.

- Any hazardous materials such as mercury, dust, vapors, PCBs and physical hazards that could be involved.
- Level of skill and training required to accomplish the task.
- Tools and type of PPE required.
- Other consideration, such as confined space operations, that could involve the safety of the workers.

5.3 Lockout/tagout

5.3.1 DCP-S-025, Lockout/tagout: prior to work being done on electrical or electro-mechanical equipment at DFRC the electrical source must be de-energized, grounded, locked or tagged out in accordance with DCP-S-025, Lockout/tagout.

5.3.2 Qualification to Lockout/tagout: only qualified Facility Maintenance, Facility Maintenance Contractor, or authorized off-site electrical contractor personnel (under contract to DFRC) may lockout/tagout DFRC electrical systems.

5.3.3 Notification: in order to safeguard sensitive electrical equipment and enhance safety the using organization must be notified, in every possible situation, when electrical power is to be shut off and for what estimated duration. Notification of electrical shut-downs generally falls under the responsibility of the Facilities Maintenance Electrical Engineer for high voltages (600 volts and greater) and to the electrical maintenance supervisor for low voltages, (less than 600 volts).

5.4 Work In Confined Space

When electrical maintenance is done in confined spaces the procedures defined in DCP-S-022, Confined Space, will be followed.

5.5 Configuration Control

5.5.1 Configuration Changes: configuration change occurs when original electrical systems are altered. When major configurations are made the Facility Design Electrical Engineer, or qualified designee, will review and sign-off the proposed electrical design changes for correctness. For day

to day operations and minor changes the DFRC Facilities Maintenance Electrical Engineer will approve of the changes. In either case, the electrical engineer will verify that required electrical codes are met. Minor circuit changes to the original system are not considered configuration changes. An example of a minor change could be the addition of electrical outlets or source routing to provide power to equipment or lights where the original system is not overloaded.

5.5.2 Change Review: the Safety, Health, and Environmental Office will review and approve applicable configuration changes for completeness. Review items are:

- Drawings of the proposed changes are certified by the reviewing electrical engineer.
- The new drawings are attached to the original drawings and made a part of the master file maintained by Facilities Maintenance Contractor.
- The Facilities System Safety Engineer (Code SH) is satisfied with the changes.

5.5.3 Equipment: electrical equipment will comply with a nationally recognized testing laboratory (NRTL).

5.6 Initial Energizing of Electrical Installations and Equipment

5.6.1 Pre-energizing Checks: protective relays and circuit breakers will be tested to their trip range. Wiring will be checked for conformity to design, fabrication, and load requirements. Motors, cables, and switching equipment will be tested to assure proper operations.

5.6.2 Initial Energizing: initial energizing of electrical circuits and equipment will be accomplished by trained and authorized electrical technicians.

5.7 Electrical Drawings and Diagrams

Completion, maintenance, updating, distribution and destroying outdated electrical drawings and diagrams of DFRC facilities is the responsibility of the Facilities Maintenance. Electrical drawings and diagrams are required for the following:

5.7.1 Building Diagrams: a plot of each building showing the partitions and physical locations of all panel boards, motor control centers, main

distribution panels, and unit power substations will be maintained by the Facilities Maintenance. These drawings should include the front view of load centers with identification numbers shown to correspond with those on the actual load centers.

5.7.2 Power Distribution Diagram: a complete line power distribution diagram of power flow from the building substations to the building load center buses and showing the circuit breakers controlling the identified loads.

5.7.3 Power Circuits: a schedule of the circuits powered by each breaker in each panel board will be shown. Every change to circuits will be shown on the panel board and updated on the appropriate diagram.

5.7.4 Power Distribution Centers: manhole, underground vaults, and duct banks that contain electrical sources.

5.7.5 High Voltage Grid Diagrams: high voltage grids and switching diagrams (usually for system of 2300V and greater) will be on file at the Facilities Engineering Branch. These diagrams will be used by certified and authorized electrical technicians to conduct maintenance on the DFRC grid.

5.8 Isolation

5.8.1 Energized Systems: work on energized electrical systems is not authorized at DFRC except by trained and authorized technicians using approved procedures and certified test equipment, tools, and PPE to:

- probe high or low voltage apparatus to verify circuit conditions.
- probe experimental equipment and systems operating at low voltages.

5.8.2 Testing Devices: only devices designed for voltage testing and rated for the circuit being tested shall be used. If testing is done on voltages of 460 V or greater the test equipment will be verified before and after the test by applying it to an energized circuit or an appropriate test unit.

5.8.3 High Voltage Lines: work on or in close proximity to high voltage equipment or lines, where a potential contact exists, shall require two (2) open breaks ("two opens") in series on all electrical phases between the work site and each energy source, including back feeds, and one open break ("one open") between the work site and any transformers. Visible protective safety grounds shall be provided either on both sides of the work site or at the actual work site.

Exception: when work is performed near but not on high voltage electrical cables and associated cable apparatus and contact is not anticipated de-energizing is not required if proper safety measures are taken. For such cases where cables or cable apparatus are de-energized for added safety purposes, one open is required and safety grounds are optional. Serious consideration must be taken before using this exceptions. Should there be any possibility of contact with a high voltage line it shall be de-energized before work is performed.

For detailed instructions for safe distances from power sources see 29 CPR 1910.333 (c), paragraphs, (i), (ii), and (iii)

5.8.4 Multiple Work Sites: when more than one work site exists on isolated high voltage source equipment or lines, such as overhead distribution lines, visible protective safety grounds shall be provided at both ends of the lines and at the work site.

5.8.5 Oil Switches: work will not be done on circuits or equipment disconnected from power source by oil switches only.

5.8.6 Low Voltage: a minimum of one open is required to isolate low voltage sources. Low voltage is 600 V or less, as defined by Federal Regulations, but may be set lower than 600 V by using organizations.

5.9 High Voltage Switching

- Opening and closing of high voltage electrical air break switches guarding circuits will be accomplished by trained and authorized electrical technicians.

- The "buddy system" will be used with a safety observer "buddy" who will stand at a safe distance, watch for unsafe conditions or procedures, and be prepared to take appropriate action in the event of an emergency.

- Disconnect poles (hot sticks) and proper PPE will be used when operating high voltage hook-stick-operated disconnect switches having open circuit voltages.

Table 1
Disconnect Pole Requirements

Voltages	Minimum length of "hot stick"
750-7,500	4 ft.
7,501-50,000	8 ft.
50,001-73,000	12 ft.

73,001-138,000	16 ft.

Hot sticks at DFRC will be made of fiberglass and be cared for in accordance with ANSI/IEEE Standard 516.

5.10 Research Modification to Electrical System

Project managers will include proposed modifications of electrical systems and equipment in their hazard analysis. Particular attention will be made to ensure normal and emergency de-energizing of equipment.

5.11 Backup Electric Source Systems

Backup electric sources are those derived from generators, certain transformers, capacitors, converters, and batteries. In many cases these power sources can "back feed" a line if not popery isolated and grounded and present unusual safety considerations. Designs for these systems will be approved by the Facilities Design Electrical Engineer.

5.12 Battery Systems

Battery systems at DFRC include those in uninterrupted power systems (UPS), aircraft, vehicles, ground support equipment, emergency lighting and warning systems, radios, and in experimental equipment. Over charging can cause vented batteries, regardless of electrolyte type, to vent excessively and cause spillage. When handling vented batteries the following safety actions shall be followed:

- Face shields, rubber gloves and apron shall be used.
- An eye wash station shall be located near by.
- Ample water shall be available to flood spills in locations where batteries are re-charged.
- No smoking, open flames, or sparking devices are permitted in battery areas.
- Provision shall be made for sufficient diffusion and ventilation of vented battery gasses to prevent accumulation.
- UPS battery installation will be reviewed by the Facilities Maintenance Electrical Engineer.

Battery electrolyte in the eyes is very dangerous. Flush eyes with copious amounts of water and seek medical help. A weak neutralizing agent suitable for the type of battery electrolyte should be kept near-by in case of spills on clothing or skin.

For additional information on battery safety see NFPA 70, NEC, Article 480, Storage Batteries.

5.13 Ladders

Only fiberglass ladders will be used near electrical sources. Metal ladders will have a stenciled warning sign on them reading; DO NOT USE NEAR ELECTRICAL EQUIPMENT.

5.14 Hazardous Classified Locations

- A hazardous classified location is one where fire or explosion hazards may exist due to the presence of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings.

- Areas that meets the definition of a hazardous location will be evaluated by the Safety Office and given a hazard classification as listed in 29 CFR 1910.307. When given a classification, electrical system and equipment will meet the requirements for the assigned classification as specified in NFPA 70.

- Organizations or experimenters using or storing materials in hazardous classified locations will follow storage procedures in accordance with the restrictions of the hazard classification. For further explanation of hazardous location classifications and restrictions see NFPA 70 (NEC). Articles 500 - 504.

5.15 Capacitors

Capacitors pose a special electrical hazard because certain ones (usually DC powered) can hold a high voltage for long periods and certain capacitors contain flammable liquids. Before work can be done on electrical equipment containing or in-line with a capacitor/s the capacitor/s must be discharged. For detailed requirements see NFPA 70, (NEC), Article 460 - Capacitors and ANSI/IEEE 18, Shunt Power Capacitors.

5.16 Temporary Wiring

- Temporary wiring for power and lighting is permitted during periods of construction, remodeling, maintenance, repair, or demolition of equipment

or structures, and during emergencies. When using temporary wiring the level of safety shall remain the same as with permanent wiring.

- Temporary wiring will be inspected and approved by the DFRC Facilities Electrical Engineer. For information regarding the use of temporary wiringsee 29 CFR 1926.405 (2), and NFPA-70, (NEC), Article 305; Temporary Wiring.

5.17 Flexible Cords and Cables

Flexible cords and cables will not:

- Be used as a substitute for fixed wiring of a structure.
- Be attached to building surface.
- Routed through holes in walls, ceilings, floors, doorways, windows, or other similar openings.
- Concealed behind walls, ceilings or floors.
- Placed where they could present a trip or fall hazard.
- Be damaged, spliced, or have a missing grounding pin.
- Installed in raceways where not permitted by NFPA-70, (NEC).
- Remain after project is completed.

Flexible cords and cables will meet requirements of NFPA-70, (NEC), Article 400, and Table 400-4.

5.18 Ground Fault Circuit-Interrupters

- 125V, single-phase, 15, 20 & 30 ampere receptacle outlets that are not a part of the permanent wiring of the building or structure and which may be used by personnel to operate electrical equipment will be protected by ground-fault circuit-interrupter protection.
- Ground fault circuit-interrupters will be used at DFRC for circuits used in construction operations even if the power source is from permanent wiring. See NFPA 70, (NEC), Article 305-6, Ground-Fault Current-Interrupters for details and exceptions.

- DFRC requires the same level of protection for laboratory employees as they would have in their homes. This requires that GFCIs be installed to protect :

  1. Outside circuits.
  2. Bathrooms.
  3. Garages.
  4. Crawl spaces.
  5. At or below ground level.
  6. Unfurnished basements.
  7. Circuits located within 6 feet of a sink or water faucet

  For details and exceptions see NFPA-70, (NEC), Article 210-8, Ground-Fault Circuit-Interrupters For Personnel.

5.19 Extension Cords

Observe the following precautions when using extension cords with either single or multiple outlets including surge protectors:

- Use only three-wire cords that are designed to carry the current being used.

- Do not use extension cords for appliances that use high currents, such as space heaters, hot plates, coffee pots, etc. These appliances must be connected to the permanent building wiring system.

- Use one extension cord per appliance. It is prohibited to daisy-chain cords.

- Inspect cords before putting them into use and ensure they are approved by a NRTL.

- Only high-visibility orange or yellow cords will be used outdoors.

- Each extension cord will be plugged into a wall receptacle. Multiple extension cords will not be connected together (daisy-chained).

5.20 Indicating Light Color Coding

Color caps showing the condition of circuit breakers or switches will be:

- Red = Contact closed
- Green = Contact open

- Amber (if furnished) = Automatically tripped to open

Color caps indicating position of a valve that allows or blocks flow:

- Green = Allows flow
- Red = Blocks flow

On electronic screens indicating positions:

- Red = Closed
- Green = Open
- White = Automatically tripped open

5.21 Entry Into Electrical Supply Stations

Entry into electrical supply stations and substations by other than trained and authorized electrical technicians will NOT be allowed at DFRC without the approval of the Facilities Maintenance Electrical Engineer and an Electrical Safety Monitor present at entry. The unauthorized entry into an electrical supply or substation by an unauthorized or non-cleared person, whether locked or unlocked, attended, or unattended will be reason or disciplinary action.

5.22 Designated Electrical Safety Monitor

The Electric Safety Monitor (ESM) is designated by the Facilities Maintenance Contractor. The ESM has the responsibility of monitoring persons who are not trained and knowledgeable of electrical hazards when they are required to enter areas where electrical hazards are present. Hazardous areas include electrical supply areas such transformer vaults, power manholes, cable tunnels, substations and other areas where exposed energized electrical sources are located.

5.23 Construction Operations Near High Voltage Sources

- Construction equipment or vehicles working near high voltage lines and apparatus will be separated far enough from the electrical source that a failure of a line or cable will not result in the energized electrical source being closer to the vehicle or equipment than the established minimums.

- Construction equipment will be properly grounded when being moved or operated in close proximity to energized sources.

- Construction operations near an energized electrical source will have a dedicated observer to warn equipment operators of potentially hazardous situations or movements.

5.24 Warning Signs and Barriers

- Warning signs of high voltage will be posted where untrained employees could come into contact with live parts.

- Appropriate warning signs and/or barriers will be used to isolate entry into areas where electrical work is being done if such work would pose a hazard to untrained persons.

- Electrical sources that pose a potential hazard to untrained persons will be secured by locks or other devices to prevent unauthorized entry.

5.25 Clearance and Working Spaces Around Electrical Equipment

- The clearances and working spaces around electrical equipment such as panel boards, switches, circuit breakers, controllers, facility equipment, and other equipment with energized exposed parts shall be adequate to accomplish all maintenance required, for emergencies, and rescue of injured persons.

Table 2
600V or less, (general requirements):

Voltage to ground	Condition 1	Condition 2	Condition 3
0 to 150 volts	3 ft.	3 ft.	3 ft.
151 to 600 volts	3 ft.	3 1/2 ft.	4 ft.

- Condition 1: exposed live parts and grounding on one side only or on two side with a insulating material between the two sides.
- Condition 2: exposed live parts on one side and grounding parts unguarded on the other with the operator between.
- Condition 3: exposed parts on both sides, not guarded as in condition 1, with operator between.

See NFPA 70, (NEC) Article 110-26 for information and exceptions for voltages less than 600 volts.

Table 3
Over 600V, (general requirements):

Voltage to ground	Condition 1	Condition 2	Condition 3
601 to 2500	3 ft.	4 ft.	5 ft.
2501 to 9000	4 ft.	5 ft.	6 ft.
9001 to 25,000	5 ft.	6 ft.	9 ft.
25,001 to 75Kv	6 ft.	8 ft.	10 ft.
75Kv and above	8 ft.	10 ft.	12 ft

- Lighting will be sufficient to allow a worker to clearly see electrical components. Workers will not reach into electrical parts without being able to clearly see components. The light source will be positioned to allow turning on and off and the changing of lamps to be done safely without a hazard of coming into contact with live parts. See NFPA 70 (NEC), Article 110-30 to 34 for exceptions and specific information such a headroom and positioning height of equipment, fences, etc., for voltages of 600 volts and greater.

- Clearances and working spaces around electrical equipment may not be used for storage.

5.26 Fuses

- DFRC personnel will not remove or replace fuses on energized circuits over 34.5Kv.

- Tools and PPE for removing and replacing fuses on unloaded energized circuits will be as follows:

  1. 50 to 450V, insulated fuse tongs or extractors.

  2. 451 to 1,000V, lineman's rubber gloves with leather protectors and insulated fuse tongs or extractors.

  3. 1001 to 34.500V, lineman's rubber gloves with leather protectors, a protective nomex suit, eye & face shields, and insulated high-voltage sticks or tongs of the proper length.

5.27 Grounding

Proper grounding and short circuiting electrical sources is an extremely important part of any electrical safety plan. Proper grounding procedures will be strictly adhered to at DFRC. For details on requirement and procedures on grounding see NFPA 70 (NEC), Article 250, Grounding and 29 CFR 1910.304. Some general grounding policies are :

- AC circuits of less than 50 volts shall be grounded if they are installed overhead and outside of building or if they are supplied by a transformer which is ungrounded or exceeds 150 volts.

- 120 Volt electrical AC circuits at DFRC will be grounded. Equipment operating on these circuits will us a three (3) prong grounded connector unless the manufacture of the equipment certifies through a NRTL that the equipment is safe using two prong or ungrounded power supply. Extension cords will also be of the three (3) prong grounded type.

- The conductor used for grounding equipment, systems, and apparatus shall:

  1. Be permanent and continuous.

  2. Facilitate operation of the circuit's protective devices.

  3. Have sufficiently low impedance to limit the voltage to ground to a safe level at all frequencies and fault-current conditions anticipated.

  4. Have the capacity with size and rating to safely conduct any fault current that may be imposed on it for the time required for protective device operation.

- Protective grounding for electrical maintenance work will be accomplished after equipment or electrical sources are de-energized and tagged and before any repair work is started. All conductors will be grounded including neutral and static conductors. Protective grounds will not be removed until maintenance personnel are finished and clear of the circuit or equipment.

- High voltage grounding such as occurs in substations, etc., must be done with extreme caution. Feedback from other sources must be guarded against. When a station grounding system is available the grounding cable will be attached to it first and then to each conductor. Maintain proper clearance from all potentially live parts until total grounding is completed. When removing grounding cables, remove them from the

conductors and then the grounding system. Personnel will stay clear of the grounding cables until they are removed from the conductors.

- High voltage grounding will be done only when both the supervisor and the workmen agree on the procedures to be taken. The Facilities Maintenance Electrical Engineer will be contacted when any questions regarding grounding exists.

- Transformers will be considered fully charged until they are de-energized, grounded, and voltage checked in accordance with the type of transformer being worked on. See NFPA 70 (NEC), Article 450; Transformers and Transformer Vaults and CFR 1926, Subpart V; Power Transmission & Distribution, for specifics in working with transformers.

- Power capacitors must be grounded in an approved manner before working on the capacitors or on equipment where the capacitor provides an energy source.

- Portable electrical equipment such as motor driven hand tools will use three (3) prong grounding plugs and receptacles. Equipment supplied with 50 volts or more will have a ground except:

  1. those driven by self-contained batteries.
  2. the case and exposed parts are protected by insulating material.
  3. equipment that is supplied by 150 volts or less where exceptions have been granted by the Safety Office.

5.28 Static Electricity

Static electricity or charge occurs when there is an imbalance of electrons on objects. Discharges can cause shocks (usually not serious) or be sufficient to ignite a flammable vapor or start a fire. Consideration for controlling static electricity are:

- Ground equipment where possible.

- Use bonding to equalize potentials between adjacent non-current carrying metal parts.

- Do not clean the face of video display terminal when the power is on.

- Do not allow electrical equipment to get wet and do not turn on wet equipment.

- In certain working condition the operator may require grounding. This may occur when working with semiconductors, sensitive electronic equipment, or with potentially ignitable or explosive materials.

6.0 RESEARCH & DEVELOPMENT, EXPERIMENTAL, AND FLIGHT LEVEL ELECTRICAL EQUIPMENT

DFRC conducts numerous research projects, both stationary and airborne, where electrical or electro-mechanic equipment is developed, tested, and used in a laboratory or project settings. The development, use, and frequent modifications of this equipment poses a special safety situation. The person who assumes the responsibility for the project, usually the project manager, will also accept the responsibility for safety for both personnel and equipment. Hazard assessment will be made periodically where experimental electrical equipment is in use in order to develop safe work practices, procedures, and the proper use of tools and PPE.

7.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personal protective equipment is essential when working on electrical supply sources or apparatus. The electrical service supervisor will ensure that workers have required PPE and that they know its limitation and are trained to use it properly. For questions regarding PPE contact the Safety Office.

7.1 Rubber Insulating Items

- Rubber insulating items such as blankets, line hose, gloves & sleeves will be inspected for damage before each use and following usage if it is suspected that damage could have occurred. These items will be replaced or be given a dielectric evaluation annually by a NRTL

- There are 5 classes of lineman's rubber gloves. It is important that the correct class is used for the job undertaken. Lineman's rubber gloves will be given an air test with each pre-use inspection and have a pertinent voltage check annually. Gloves will be maintained in accordance with ASTM D120, Standard Specifications for Rubber Insulating Gloves. Also see 29 CFR 1910.137, Table I-5 - Rubber Insulating Equipment Voltage Requirements for glove classes and voltage limits .

- Rubber insulating gloves will be constructed of three-ply insulating rubber sheets. The outer ply shall be constructed of stretched black rubber and the inner ply of non-black (yellow is preferable) heavy sheet rubber. This combination allows the inner lining to show should

a cut or puncture occur. If the inner liner shows the gloves will be discarded.

- Leather protectors will be worn with lineman's gloves except as exempted in 29 CFR 1910.137.

- Each certified switchman will have a personal pair of lineman's gloves with leather protectors and a glove bag. The Chief, Facilities Maintenance will determine if additional gloves and protectors need to be stored in high voltage substations for emergency use.

7.2 Hard Hats

Anyone entering a high voltage electric source station, cable tunnel, cable room, transformer vaults, manholes containing high voltage, or other areas containing high voltage sources where electrical maintenance is being done will wear a Class-2 hard hat. See 29 CFR 1910.135 or ANSI Z89.1, Industrial Workers Protective Headwear, for details.

7.3 Safety Shoes

Persons who enter high voltage source areas will wear safety shoes in accordance with 29 CFR 1910.136 or ANSI Z41, Protective Footwear.

7.4 Protective Suits

Protective suits made of Nomex or suitable flash-resistant material such as cotton coveralls will be worn when:

- Opening or closing 2400 volt or greater oil cutout switching devices.

- Removing or installing links in high voltage cable tap boxes.

- Removing or installing fuses in high voltage circuits.

- Anytime when conditions suggest that an arc, flash, or electrical explosion is a possibility.

Note: There are numerous case histories where a combination of flash resistant suits, hand, and eye and face protection have protected workers exposed to arcs and explosions where without the PPE fatalities would have occurred. An electrical arc blast or explosion can kill an unprotected person as far away as 20 feet. Always prepare for the worst case when selecting PPE.

7.5 Eye and Face Protection

Eye and face protection will be used when there is a danger of flying objects, electrical arcs or flashes, and explosions. Safety glasses will have non-metallic frames. Full face shields will be used to protect the full face when working with high voltages. See ANSI Z87.1, ...Eye and Face Protection.

7.6 Disconnect Poles (Hot Sticks)

See 5.9, High Voltage Switching; Table 1, for disconnect pole specifications.

8.0. EMERGENCY PROCEDURES

8.1 Emergency Telephone System

- The DFRC emergency 911 telephone system is the primary means to alert the security command post and emergency response personnel. If for any reason the DFRC 911 emergency system can not be used the AFTTC emergency system will be used by dialing 41-911 from any DFRC telephone. The Emergency 911 system will be used when:

  1. A person has been injured or there is a condition that jeopardizes persons or equipment.

  2. The power supply to all or portions of the Center is in jeopardy.

  3. A non-scheduled outage occurs that affects major portions of the Center.

- Scheduled electrical outages will be during non-work periods, when possible, and will be announced on the Center paging and e-mail systems to allow for the protection of sensitive electrical equipment.

9.0 TRAINING and CERTIFICATION

9.1 DFRC Employees

Employees who perform electrical work shall be trained to recognize the hazards associated with their work and how to mitigate the risks of accidents and injuries. The amount of training will be dictated by the risk associated with the employees job requirements. Persons working on high voltages, by definition, will be certified. Training will be by qualified instructors and include both classroom and on the job training. Universities and trade schools may also be

a source of training. The responsibility for ensuring employees are qualified to perform their jobs rests with management, supervisors, and the worker. As a minimum DFRC electrical maintenance workers will be trained in and be familiar with:

- The skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment .
- The skill and techniques necessary to determine the nominal voltage of exposed live parts.
- The clearance distance specified in 29 CFR 1910.333 and the corresponding voltages to which the qualified person will be exposed.
- The proper use, care, and limitation of PPE to include fit tests where required.
- The responsibilities of safety observers (buddy system).
- Practices, policies, and procedures necessary to safely accomplishing an assigned task.

9.2 Certification

Federal regulations requires those persons working with voltages of 600 Volts and greater (high voltage) to be certified. An organization may declare a lower voltage as the start point for "high voltage," therefore, causing certification to be required for lower voltages.

9.3 CPR and First Aid Training

Both high and low voltages are capable of stopping the heart or causing arrhythmia (abnormal heart beat). In these situations the victim may need assistance in regaining a normal heart beat, therefore, it is mandatory that electrical service personnel who work on voltages at or above 500 V be trained in both cardiopulmonary resuscitation (CPR) and First Aid. It is recommended that electrical service personnel who work with low voltages also have current CPR training. CPR and First Aid training is provided by the DFRC Health Unit.

9.4 Records

Training and certification records include:

- Certification for work on high voltage systems.
- Formal electrical service training courses.
- On-the-job training.
- CPR and First Aid.

Maintenance of training and certification records will be the responsibility of the employee's supervisor. These records may be kept by the supervisor or in a central location accessible to the supervisor, employee, and safety inspectors. On-site contractors are responsible the maintenance of their employees records.

Following the termination of an employee a disposition for the training records will be made by the supervisor using NPD 1441.1: Records Retention Schedules; 33 [3400] N 15-38, G., Technical Training, as a guide.